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(54) **PERSONAL VAPORIZER WITH LIQUID SUPPLY BY SUCTION**

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CPC A61M 15/06; A24F 47/00; A24F 47/02; A24F 47/004; A24F 47/008
See application file for complete search history.

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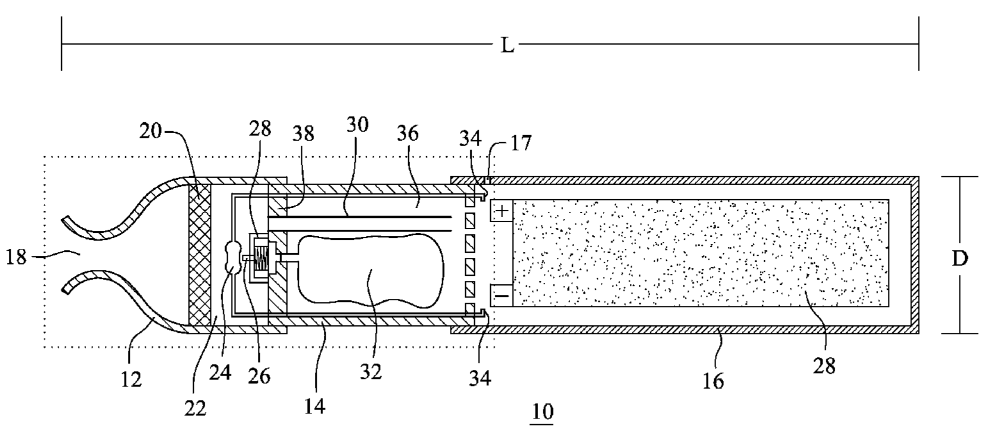
(57) **ABSTRACT**

A personal vaporizer including a pressure-induced liquid transport device that allows a user to draw liquid from a liquid reservoir through applying a suction force on the mouthpiece. The amount of liquid drawn is proportional to the pressure induced, and proportional to the amount of vaporization a user may desired.

45 Claims, 3 Drawing Sheets



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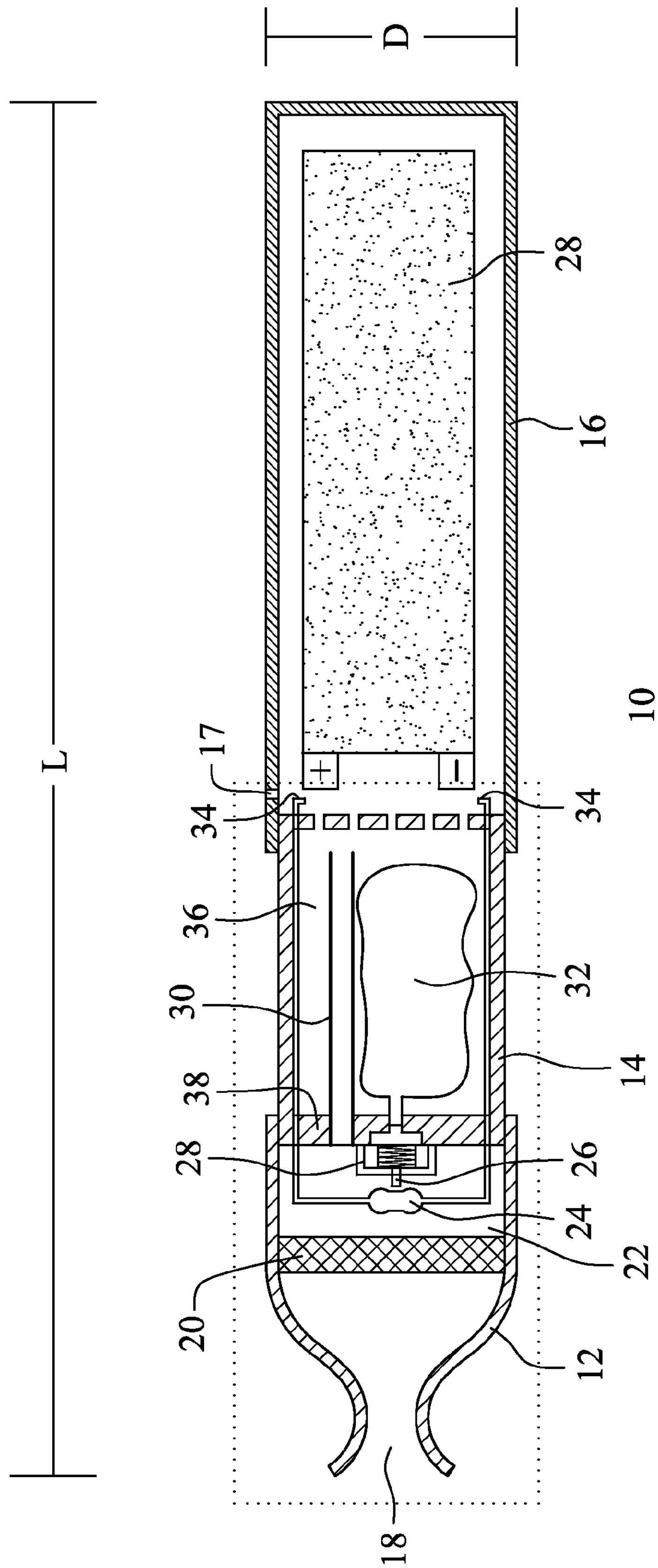


FIG. 1

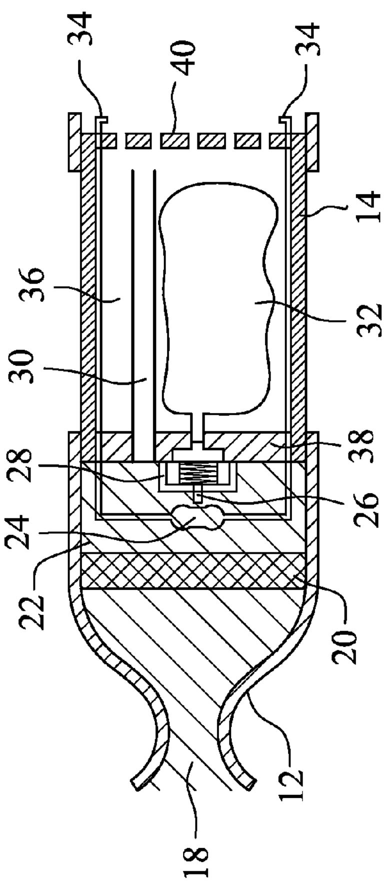


FIG. 2

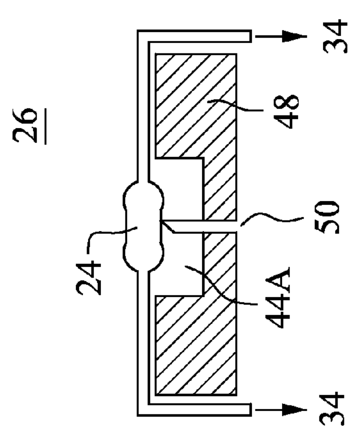


FIG. 3A

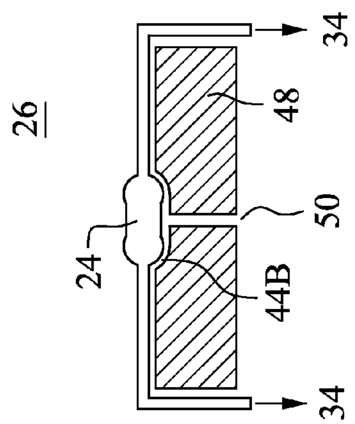


FIG. 3B

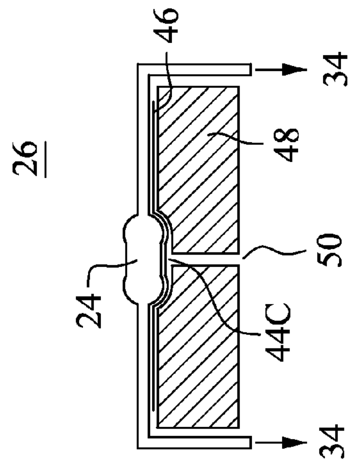
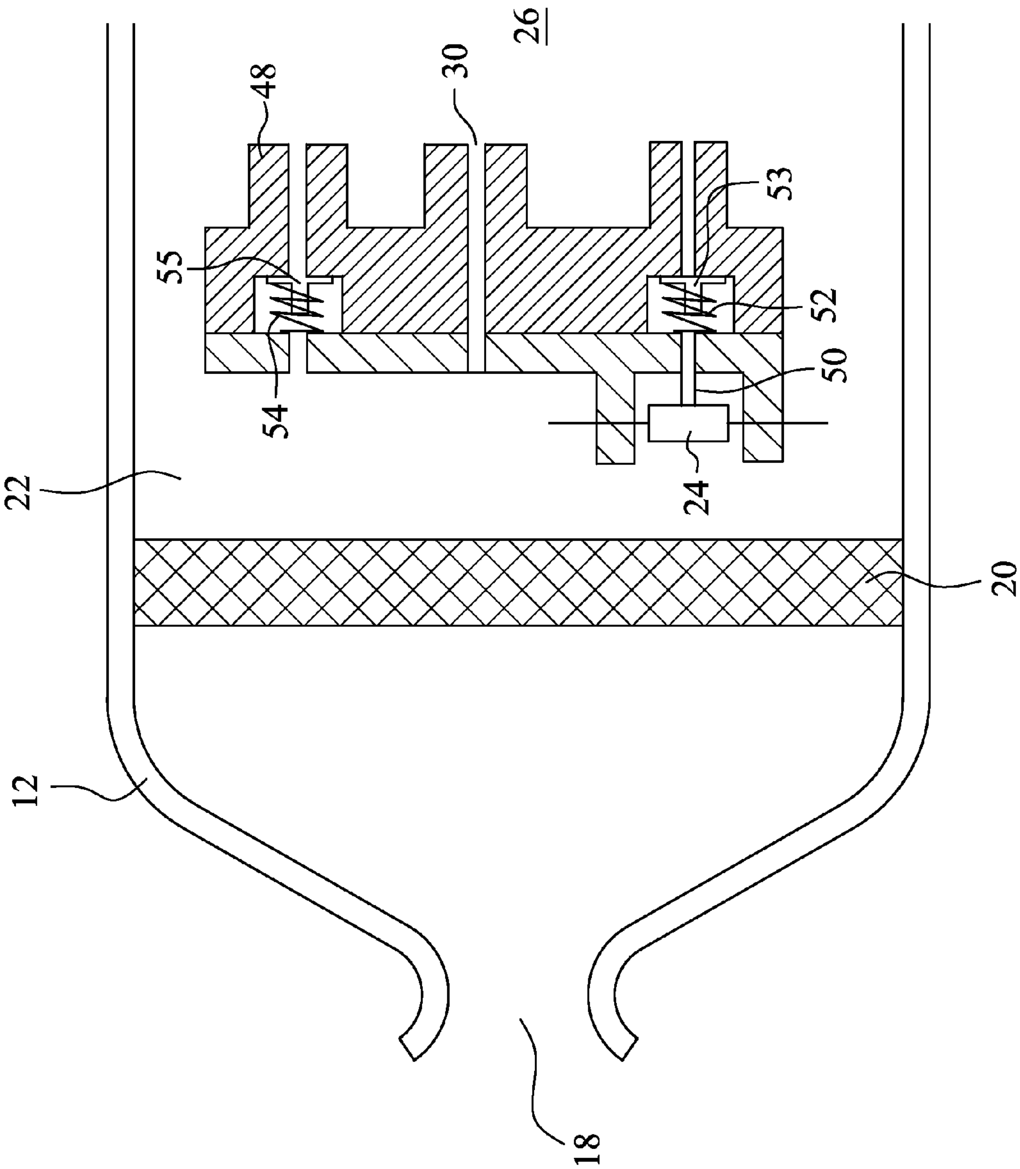


FIG. 3C

FIG. 4



PERSONAL VAPORIZER WITH LIQUID SUPPLY BY SUCTION

BACKGROUND OF THE DISCLOSURE

The present disclosure generally relates to micro-vaporizers and particularly to micro-vaporizers for small handheld devices.

Vaporizers convert a liquid or solid into a vapor typically by heating to promote evaporation. Many products have micro-vaporizers that typically vaporize liquids at a rate of less than 50 milliliters per hour (ml/h). The vapor may be inhaled, dispersed in the air to create a scent, or used in some other manner. Micro-vaporizers may be used in products such as electronic cigarettes, fragrance dispensers, milliliters per hour mosquito, or other bug repellent diffusers, air and environment purification units, and essence or aromatic diffusers.

Micro-vaporizers may be used in electronic cigarettes to produce a vapor from nicotine liquid in place of the smoke created by the burning of tobacco products. As a user inhales from an electronic cigarette, a flavored, nicotine-containing liquid contained in the cigarette is heated to produce vapor. A battery in the cigarette may be used to power a heating element. The heater rapidly heats the liquid to generate the vapor that simulates smoke.

Users may prefer that their electronic cigarettes have characteristics similar to tobacco cigarettes. The size and shape of both types of cigarettes may preferably be about the same. Tobacco cigarettes generate smoke almost instantaneously when a user inhales. An electronic cigarette preferably also generates vapor almost instantaneously. Tobacco cigarettes are generally cheap and disposable; thus, cheap and disposable electronic cigarettes may also be commercially desirable.

Structurally, conventional electronic cigarettes use fiber strings to draw or direct liquid stored in a reservoir towards the surface of a heating element to vaporize the liquid. The fiber strings are directly in contact with the surface of the heating element. The conventional fiber strings may have problems in the heat transfer efficiency and fluid leakage.

In the conventional structure, liquid is directed or drawn by a fiber string that is in close or direct contact with the heating element surface. Because liquid is absorbed by the fiber strings, vaporization occurs on the surface of the fiber string. Consequently, mainly the liquid on the surface of the fiber strings is vaporized and remainder of the liquid absorbed into the fiber strings is heated but does not vaporize. Heating a liquid that do not vaporize causes excessive power usage, which may drain the battery in the cigarette.

The conventional fiber string structure tends to allow liquid to leak because the liquid continues to seep into fiber string while the cigarette is not in use. The liquid absorbed in the fiber string may leak through the open vapor channel and exit through the mouthpiece.

Further, fiber strings tend to absorb liquid in proportion to the diameter of the string. The amount of liquid adsorbed by the strings generally is more than the amount of liquid needed to convert to vapor in a volume that a user may desire during a single inhalation.

Also if a user applies a small suction force, the excessive amount of vapor in the vapor channel may condense and become a liquid form. The condensed liquid may be unable to be recaptured and vaporized, and thus leak through the mouthpiece.

Electronic cigarettes typically have a heating element that quickly heats up to generate vapor. Other types of conventional vaporizers may use a direct flame to vaporize liquid but flames may not be suitable for an electronic cigarette.

Further, a user may need to learn and become accustomed to an electronic cigarette or other type of vaporizer. The user may need to adjust to the heating time and method of each type of conventional vaporizers. For example, the conventional vaporizers that use tube delivery systems may require the users to learn the proper draw speed of the vaporizer, and the vaporizers that use flame powered units may need to learn the correct flame distance and draw.

One type of commercially desirable electronic cigarette shape may be similar to a conventional tobacco cigarette. It may be challenging to develop electronic cigarettes that have characteristics similar to tobacco cigarettes, such as the small diameter, cylindrical shape, and compact portability of a tobacco cigarette. One of the difficulties is that the desired shape and size of a conventional tobacco may not fit conventional batteries, such as an alkaline battery. The electrical energy discharge rate needed to heat and vaporize the liquid in an electronic cigarette may exceed the energy stored in low-cost conventional batteries and conventional rechargeable batteries. Batteries that store and discharge large amounts of energy, such as lithium batteries, are typically expensive, and may not be viable for a disposable electronic cigarette.

In view of these challenges and others, there continues to be a long felt and unmet need for low cost, lower energy consumption, and controllable vapor capacity micro-vaporizers for electronic cigarettes and other similar devices.

SUMMARY OF INVENTION

To efficiently vaporize liquid and prevent leakage, sufficiently high temperature may be required to be supplied to a small surface area of liquid that is proportional to a user's applied force. In particular, the most efficient process to vaporize liquid in an electronic cigarette may be to vaporize a proportionately sufficient liquid to produce a desired amount of vapor by applying liquid directly to the surface of the heating element.

An embodiment of the invention addresses the desired characteristic by providing an electronic cigarette having a mouthpiece including an opening, a vaporization chamber housing a heating element and a liquid transportation device, and a liquid storage chamber housing a liquid reservoir and an air duct that communicates between the vaporization chamber and the liquid storage chamber.

The invention further includes the vaporization chamber being adapted to have a lower pressure than the liquid storage chamber.

An embodiment of a liquid transport device in an electronic cigarette may have a support body of a liquid transport device, a cavity in the support body, and an opening in the cavity that is in close proximity to a heating element such that an amount of liquid less than a natural droplet can be supplied to the heating element.

The invention further includes a method to produce vapor in an electronic cigarette by: 1) providing a suction force to a mouthpiece of an electronic cigarette through a mouthpiece opening, 2) inducing a negative pressure in the mouthpiece, 3) drawing an amount of liquid from a liquid reservoir through an opening in a liquid transport device of the electronic cigarette due to the negative pressure induced, 3) supplying the amount of liquid drawn from the liquid reservoir onto a heating element, and 4) producing vapor using the liquid supplied to the heating element by heating the vapor on a surface of the heating element.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram showing in cross-section a first embodiment of a personal vaporizer, such as an electronic cigarette.

FIG. **2** is an enlarged cross-sectional view of a portion having the mouthpiece, heating element, and liquid reservoir of the electronic cigarette shown in FIG. **1**.

FIG. **3**A is an enlarged view of a first embodiment of the heating element and liquid delivery system including a tube inside the mouthpiece shown in FIG. **1**.

FIG. **3**B is an enlarged view of a second embodiment of the heating element and liquid delivery system without a tube inside the mouthpiece shown in FIG. **1**.

FIG. **3**C is an enlarged view of a third embodiment of the heating element and liquid delivery system including a membrane layer inside the mouthpiece shown in FIG. **1**.

FIG. **4** is an enlarged schematic diagram of a fourth embodiment of the heating element and liquid delivery system for a larger micro-vaporizer, such as for an electronic cigar.

DETAILED DESCRIPTION OF THE INVENTION

This invention is directed to provide an efficient vaporization method that may be applied to a personal vaporizer, such as an electronic cigarette.

As a user inhales through a mouthpiece of an electronic cigarette described herein, a negative pressure is created in a vaporization chamber. The negative pressure is used to: 1) drawn fresh air into the electronic cigarette through vent holes; 2) may activate an "air-pressure sensitive" on and off flow switch; and 3) draw liquid from a reservoir onto a heating element in the electronic cigarette for immediate vaporization upon contact with a surface of the heating element. The amount of vaporization may be controlled by the user through controlling the amount of suction force applied to the electronic cigarette.

FIG. **1** is a schematic diagram showing in cross-section an embodiment of a personal vaporizer, such as an electronic cigarette **10**. The cigarette **10** may have a generally cylindrical shape with a diameter (D) of about 10 millimeters (10 mm) and a length (L) of between 75 to 120 mm. These are the dimensions of a conventional tobacco cigarette. The dimensions may vary depending on the embodiment of the cigarette **10** and on whether the electronic cigarette **10** is to have the same dimensions of a tobacco cigarette.

In another embodiment, the personal vaporizer may not be in a cylindrical shape as shown in FIG. **1**, and may be in different shapes that may be desirable to a user, and may include similar components as described herein.

The electronic cigarette **10** is one embodiment of a personal device including a micro-vaporizer. Other applicable devices may include small hand-held or pendant type dispensers for fragrance, bug repellant and other vapors or mist products. In another embodiment, the personal device may use a micro-vaporizer to deliver medicine or other therapeutic vapor or mist.

The electronic cigarette **10** may include a mouthpiece **12**, a proximal cylindrical housing section **14** and a distal cylindrical housing section **16**. The mouthpiece is hollow and includes a mouthpiece opening **18** that allows vapor to pass from the cigarette **10** into the mouth of a user. The mouthpiece **12** may house a mouthpiece membrane **20** that is in close proximity to the opening **18**. The membrane **20** may be, e.g., a porous filter, a non-fibrous material, a woven material, a non-woven fibrous material, a highly absorbent breathable material, or any other types of material that has the ability to absorb liquid droplets in the mouthpiece or vapor condensates during the vaporization process. The membrane **20** may have the ability to absorb up to ¼ of the liquid in a liquid reservoir used in the electronic cigarette. The membrane **20** may be disc shaped, rectangular shaped, triangular shaped, or a combination of the shapes, and may entirely fill the hollow interior of a portion of the mouthpiece. The membrane **20** may catch liquids in the vapor so that liquid may not leak from the mouthpiece opening **18**.

The mouthpiece **12** may also contain a vaporization chamber **22** on the opposite side of the membrane **20** from the opening **18**. The vaporization chamber **22** may house a heating element **24**, a liquid transport device **26** connected to a one-way valve **28**, all of which may be located on and/or supported by a proximal housing support **38**. The proximal housing support **38** provides a substantial divider between the mouthpiece **12** and the proximal cylindrical housing section **14**.

The proximal cylindrical housing section **14** may contain a liquid storage chamber **36** that is defined by the proximal housing support **38** and a distal housing support **40**. The liquid storage chamber may include at least one air duct **30** that communicates between the vapor chamber and the liquid storage chamber, and a liquid reservoir **32** that includes an opening that may be connected to and controlled by the one-way valve **28** and the liquid transport device **26**. The liquid reservoir **32** may be preferably designed to contain at least enough liquid to supply vapor during at least one session.

The distal housing support **40** may be designed to have at least one opening, or other passages that allow air to pass through the support **40**. These openings or passages provide fluid communication between the liquid storage chamber **36** and the distal cylindrical housing section **16**. The distal cylindrical housing section **16** may include at least one vent **17** that provide an opening to the atmospheric environment. Vent **17** may supply air into the distal cylindrical housing section **16**, and through the distal housing support **40** into liquid storage chamber **14**.

The user inhales vapor from the cigarette **10** in a cyclical manner. During each cycle, the user may inhale for a few seconds. The amount of vapor inhaled by the user during each cycle is referred to as the "vapor volume." The heating element **24** preferably produces sufficient vapor volume to satisfy the user's desire for vapor during each cycle. The user may pause between each period of inhaling vapor. The duration of the pause may vary from very short, e.g., one or two seconds, to relatively long, e.g., ten to 30 seconds. During each session, the user may repeat the cycle of inhaling vapor and pausing. The duration of each cycle and the number of cycles may vary. The vapor volume produced by the heating element **24** may be dependent upon the amount of liquid supplied to the heating element as induced by a user's inhalation habits, the liquid may be drawn through the liquid transport device **26** and the one-way valve **28**.

In an embodiment, the one-way valve **28** may enable liquid to be drawn from the liquid reservoir **32** and pass through the proximal housing support **38** to enter the vapor chamber **22**. The one-way valve **28** may not allow liquid to flow in the opposite direction and reenter the liquid reservoir **32**. Liquid is drawn from the liquid reservoir **32**, through the valve **28** and is applied to a surface of the heating element **24**. The valve **28** is actuated, e.g., opened, by applying a suction force to the mouthpiece **18** and to induce a pressure change between the vaporization chamber **22** and the liquid storage chamber **36**. When the valve **28** is open, the fluid moves from the reservoir **32**, through the valve **28** and to the heating element **24** due to the pressure difference between the reservoir **32** and the heating element **24**.

FIG. **2** depicts pressure differences that may be induced in the mouthpiece **12** and the proximal cylindrical housing section **14**. A user applies a suction force on the opening **18**, and the force may induce a negative pressure in the mouthpiece **12** as compared to a positive pressure in the liquid storage chamber **16**. The positive pressure zone is open to the atmosphere through vent **17** in the distal cylindrical housing section **16**. The negative pressure, e.g., a pressure slightly below atmospheric pressure, may be induced in the entire mouthpiece **12** portion, including the opening **18** and the vaporization chamber **22**.

When a negative pressure is induced, the negative pressure in the mouthpiece **12** would force air to be drawn from the positive pressured liquid storage chamber **32** through the air duct **30**. The pressure would also force liquid to be drawn through an opening in the liquid transport device **26** and the attached one-way valve **28**. Simultaneously, the force that draws air from the liquid storage chamber **36** would also induce air to be drawn from the vent **17** in the distal cylindrical housing section **16** to replace the air drawn from the liquid storage chamber **36**.

The liquid drawn into the vaporization chamber **22** by the negative pressure in the mouthpiece **12** is applied to a surface of the heating element **24** and vaporized in the vaporization chamber **22**. When a vapor is produced, the user then may apply more suction force and inhale the vapor. The inhalation act by the user would induce further negative pressure in the mouthpiece **12**, and repeat the process of drawing liquid from the liquid reservoir **32**, thus producing more vapor in the vaporization chamber **22**.

However, because the mouthpiece **12** and the liquid storage chamber **22** are able to communicate through the air duct **30**, the pressure difference induced is only formed for a short period of time, and then the pressure is rebalanced as air is drawn into the mouthpiece **12** from the liquid storage chamber **36** that is open to the atmosphere through the at least one opening in the distal housing support **40** and the vent **17**. Thus, the amount of liquid drawn from the liquid reservoir **32** due to the decrease in pressure in the mouthpiece **12** may be minimal, and proportionate to the pressure difference.

The pressure difference induced in the mouthpiece **12** may be directly related to the suction force applied by a user on the opening **18**. An increase in the suction force a user applies on the opening **18** may also increase the negative pressure induced in the mouthpiece **12**. As the pressure becomes more negative in the mouthpiece **12**, the pressure difference increased between the mouthpiece **12** and the liquid storage chamber **36**. As the difference increases, liquid drawn from the liquid reservoir **32** also increases. Thus, more liquid would be applied to the surface of the heating element **24**, and vapor produced would also increase.

The liquid reservoir **32** may be a collapsible liquid reservoir **32** and may resemble a bladder that is made of a plastic, a little or non-elastic thin film, or any type of material that is collapsible and may hold liquid or a solid tube with an inside sliding plug. The liquid reservoir **32** may be enlarged when filled with a desired liquid to be vaporized. As liquid is drawn from the reservoir, the liquid reservoir **32** may collapse and shrink. The liquid reservoir **32** may be filled with only liquid, without any gases inside the liquid reservoir **32**. The pressure of the liquid in the liquid reservoir **32** may remain constant, e.g., at atmospheric pressure.

When a user induces negative pressure in the mouthpiece **12**, the positive pressure in the liquid storage chamber **36** may cause the liquid reservoir **32** to collapse or shrink. The liquid reservoir **32** may be open to the environment at only the liquid transport device **26** and one-way valve **28** such that the liquid reservoir **32** may not draw air from the environment into the liquid reservoir **32**. The collapsible design of the liquid reservoir **32** may enable a user to use the device and draw liquid from the liquid reservoir **32** regardless of the orientation of the device during the vaporization process.

FIGS. 3A, 3B, and 3C depict three embodiments of a liquid transport device **26** that may be used in an electronic cigarette or other type of vaporizer, such as one described above and shown in FIG. **1**. The liquid transport device **26** may be designed to apply liquid onto a surface of the heating element **24** in an efficient manner that does not require the use of, or produce, excess liquid drawn from the liquid reservoir **32**.

The liquid transport device **26** may also be designed to apply liquid onto the heating element **24** to allow instantaneous vaporization as the user's applies a suction force to the opening **18** by heating only an amount of liquid drawn by the suction force to create the vapor volume desired by the user. The remaining amount of liquid may be stored in the liquid reservoir **32** which is separated from the heating element **24**. The liquid in the liquid reservoir **32** is not heated as the user inhales the vapor. Thus, the liquid in the reservoir **32** does not cool the heating element **24** or cause additional energy to be drawn from a power source. The liquid may only flow from the reservoir **32** to the heating element **24** as needed to create the vapor volume.

An electronic cigarette user may consume vapor at an average of a minimum amount of about 0.15-0.75 μl and a maximum about of about 15-30 μl, and have an inhalation period of between about 0.5-5.0 seconds. These values are exemplary and do not limit the scope of the invention. When a user has a short inhalation period, the vapor production desired may be relative to the inhalation period, and thus the liquid required is a small amount. The liquid desired to be vaporized at a minimum amount of vapor inhalation may be less than a natural droplet.

The liquid transport device **26** may be designed to allow efficient vaporization such that the entire amount of liquid drawn is an amount that can be instantaneously vaporized. The vaporization amount may also be controlled such that the entire vapor produced is consumed by a user during a single inhalation cycle to prevent condensation and leakage in the mouthpiece.

To draw a liquid amount that may be efficiently vaporized and produce a small amount of vapor, the liquid transport device **26** may have an opening of about 2.5 mm or less in diameter, and may be as simple as having an aperture having the size of a pin hole. The opening of the liquid transport device **26** may be close in proximity to the heating element **24**. The close proximity of the liquid transport device **26** to the heating element **24** may allow liquid to be supplied regardless of the orientation of the electronic cigarette **10**. The size of the opening may allow a minimum amount of liquid desired to be vaporized to be drawn from the liquid reservoir **32**, allow liquid to be drawn even if the liquid amount may not be enough to form a natural droplet.

It may be desirable to draw different amounts of liquid depending on the desired vapor production capacity of the electronic cigarette **10** in addition to the user-applied force. Adjustments in vapor production capacity may be obtained by changing the size of the air duct **30** relative to the opening in the liquid transport device **26** or adjusting the spring bias of the one-way valve. For example, if the opening in the liquid transport device **26** remains constant, the larger the diameter of air duct **30**, the lesser the amount of liquid may be drawn from the liquid reservoir **32**. In another example, reducing the spring bias would cause the valve to open more quickly and stay open longer to allow more liquid to flow through the valve. These adjustments would be made during the design of the electronic cigarette and not during its use.

FIG. **3**A depicts a liquid transport device **26** that applies liquid to a heating element **24**. The liquid transport device **26** may comprise a support body **48**. The liquid transport device **26** may be coupled to the liquid reservoir **32** on a first side of the proximal housing support **38**, through an opening in the proximal housing support **38**, liquid may be supplied to the liquid transport device **26** on a second side of the proximal housing support **38**, and applied to the heating element **24**. In another embodiment, the support body **48** may comprise the proximal housing support **38**.

The liquid transport device **26** may be connected to a support body cavity **44**A in the shape of a rectangle that is on a first side of the support body **48**, and the cavity **44**A may include an opening **50**. The liquid transport device **26** may comprise a tube that extends through the opening **50** in the cavity **44**A to deliver the liquid drawn from the liquid reservoir **32** to the heating element **24**. The tube may be less than 1 mm in diameter, and may be made of a material such as a hard, stiff plastic or metal. The tube may have a slanted cut at the tip which is close, e.g., within 3 mm, to the heating element. The opening of the tube with the slant cut assists in delivering small amounts of liquid, e.g., smaller than a drop, to the surface of the heating element. The slanted cut at the end of the tube may also assist in preventing an air bubble blockage in the tube or a blockage due to liquid remaining in the tube.

FIG. **3**B depicts another liquid transport device **26**. The liquid transport device may be coupled to a support body cavity **44**B, in a shape of a basin, on a first side of the support body **48**, and the cavity **44**B includes an opening that extends through the support body **48** to a second side of the support body **48**. The liquid transport device may comprise of the cavity **44**B and the opening **50** in the support body **48**, the opening **50** being coupled to a liquid reservoir **32** on a second side of the support body **48**.

The heating element **24** is in close proximity to the support body **48** such that the heating element **24** is situated within the basin of the support body cavity **44**B. The liquid is drawn from the liquid reservoir **32** and enters the opening **50** of the support body **48**. The liquid diffuses into the basin of the cavity **44**B to distribute the liquid onto the heating element surface.

FIG. **3**C depicts another liquid transport device **26**. The embodiment may comprise of a basin cavity **44**C that resembles the basin cavity **44**B shown in FIG. **3**B, and a membrane layer **46** between the cavity **44**C and the heating element **24**. The membrane layer **46** may cover an outer surface of the heating element in its entirety, only on the outer surface of the heating element **24** that abuts the basin cavity **44**C, partially cover the heating element along the basin cavity **44**C, or may cover a thin strip of a surface of the heating element **24** that is perpendicular to the opening **50** in support body **48**. The membrane layer **46** may cover between about 10-100% of the outer surface of the heating element **24**, and may be of a thickness of between about 0.1 mm to about 5 mm, for example.

The membrane layer **46** aids in the diffusion of the liquid along the basin cavity **44**C such that the liquid is drawn through the opening and absorbed onto the membrane layer **46**, and be instantaneously vaporized from the membrane by the heating element **24**. The membrane layer **46** may cover a surface area of the heating element **24** sufficient to provide the liquid to the heating element needed for the desired amount of vapor generation. The membrane layer **46** may be made out of paper, cloth, fiber, lipids, or other type of absorbent coating on the surface of the heating element **24**.

The support body **48** may be made out of a durable material that can endure high temperatures, such as ceramic or plastic, or any other material that is non-absorbent and can endure high temperature. The bracket **48** may also be designed to envelope the heating element **24** entirely except for an opening for vapor to escape. The bracket **48** may also be designed to cover between about 15-99% of the outer surface of the heating element **24**, or between about 25-75% of an outer surface of the heating element **24**.

The liquid transport device **26** may be coupled to a one-way valve **28**. The one-way valve may remain closed to prevent liquid flow from the reservoir. The valve is opened when a slight pressure difference, e.g., 200 to 400 Pa or 0.03 to 0.05 psi, occurs between the reservoir and the vaporization chamber. These pressure differences correspond to the suction created when a person inhales on the mouthpiece.

In an embodiment, The one-way valve **28** may be coupled to the liquid transport device **26** to ensure that no air flow may enters the liquid reservoir **32**, and no liquid flow may reenter the liquid reservoir **32** during the occurrence of any circumstances that may cause air flow to be redirected, such as if a user blows into the mouthpiece **18**.

FIG. **4** depicts another embodiment of a liquid transport device **26** that may be used within a micro-vaporizer that operates at a larger capacity, such as an electronic cigar or the like. The liquid transport device **26** may include a support body **48**, the support body **48** may enclose a first and a second cavities: the first cavity houses a plunger valve **53** that may include a spring **52**, which connects to the heating element **24** via a tube **50** that extend through the support body **48** from the cavity to the heating element; and the second cavity houses a bleed valve **55** that may also include a spring **54** which activates upon an air pressure threshold increase in the liquid storage chamber to release air flow into the vaporization chamber **36**. The support body **48** may also include an air duct **30** that extends between the vaporization chamber **22** and the liquid storage chamber **36**.

The spring **52** may bias the plunger valve **53** against the first cavity to flow passages in the support body **48** that may be coupled to the liquid reservoir **32**. The cavities in the support body **48** may be in the form of a cage for the plunger valve **53**. The support body **48** may allow liquid to flow through the plunger valve **53** to flow to the heating element **24**. Activation of the plunger valve may be by air pressure that is induced from a user's suction force, or through a switch that may be engaged. The force of the spring **52** may be selected such that it may be overcome by the slight pressure difference between the vaporization chamber **22** and the liquid reservoir **32** created when the user sucks on the cigarette **10**. When suction is applied, the plunger valve **53** may open and liquid may flow to the vaporization chamber **22**. When suction is not applied, the valve may remain closed and liquid may not flow from the liquid reservoir **32**.

Air duct **30** supplies air to the vaporization chamber that is mixed with vapor and inhaled by the user. The air duct is sized to allow sufficient air needed to be inhaled and create the needed reduced pressure condition in the vaporization chamber to actuate the one way valve. The air duct **30** may have a throat diameter, e.g., the minimum diameter in the duct, of no greater than the diameter of the throat opening **31** of the mouthpiece. For example, if the mouth piece has a throat diameter of 3 mm the throat diameter of the air duct **30** would be 3 mm or less, such as 1 mm.

A bleed valve **55** may aid in the process of ensuring that air pressure in the electronic cigarette remains stable. When a user's applied suction force exceeds the maximum air intake threshold, the bleed valve **55** may open and divert airflow to allow a greater air flow into the vaporization chamber. A bleed valve **55** may be used in an electronic cigar which tend to have a larger throat diameter for the mouthpiece than do electronic cigarettes. The bleed valve **55** avoids the user having a feeling that insufficient air and vapor are flowing through the mouthpiece.

The combined use of the plunger valve **53** and bleed valve **55** may aid in the control of liquid flow from the liquid reservoir **32** to the heating element **24** such that vaporization occurs at an efficient rate as desired and controlled by the user. The temperature of the heating element **24** may be adjusted by changing the output of the heating element **24**, such as changing in voltage or resistance of the heating element, changing the electrical impedance, or changing the amount of current used in the electronic cigarette **10**.

Control may be adjusted such that full vaporization may be achieved even during the maximized condition, and retain the ability for a user to control the amount of fluid vaporization and condensation. Efficiency in vaporization may allow use of a minimal amount of power required to vaporize desired liquid, and improve the portability of an electronic cigarette by decreasing the need for a large housing to hold power supply, such as a battery.

Relating back to FIG. **1**, a power source, such as a battery **28**, may be housed in the distal cylindrical housing **16**. proximal cylindrical housing section **14** may connect to, or may be integral with, the distal cylindrical housing section **16**. The connection may be formed by opposing ends of the housing sections **14** and **16** engaging each other, such as by sliding one onto the other. The battery **28** in the distal cylindrical housing section **16** may provide electrical energy or power to the heating element **24**. In an embodiment, the distal cylindrical housing section **16** may also include an illuminating end, e.g., a light emitting diode, to simulate a lit end of a tobacco cigarette.

One approach to minimizing the requirement for stored energy is to reduce the power needed to vaporize the liquid. The power is used by the heating element to create heat that vaporizes the liquid. The liquid cools the heating element. Power from the battery is required to overcome the cooling by the liquid and heat the temperature to a needed to create vapor. The more liquid on or near the heating element, the greater the cooling of the heating element. By reducing the amount of liquid applied onto or near the heating element, the amount of power needed to vaporize the liquid may be reduced. The power consumption of the cigarette may be reduced by heating only a sufficient amount of liquid to create the desired vapor volume. Thus, portability of an electronic cigarette **10** may be dependent upon the efficiency in liquid flow supply by the liquid transport device **26** as described in FIGS. **3**A, **3**B, **3**C, and **4** above, to the heating element **24**.

The heating element **24** may be formed with conductors that extend from the vaporization chamber **22**, through the proximal housing support **38** and the liquid storage chamber **36**, and the ends of the conductors extend into the distal cylindrical housing section **16**.

In an embodiment, the user of the cigarette **10** may apply a suction force on the mouthpiece opening **18**. The suction applied to the mouthpiece opening **18** of the cigarette **10** may create a slight reduced pressure in the cigarette **10**. The difference in pressure may be detected by a pressure sensor, and the pressure sensor may activate the heating element **24**. In one embodiment, the sensor may also activate a light emitting diode (LED) at the distal end of the cigarette to show that the electronic cigarette **10** is in use.

The activated heating element **24** may heat the liquid to create vapor. The heating element **24** may continue to heat the liquid and generate vapor until deactivated, e.g., turned-off. The heating element **24** may be turned off when the pressure sensor detects a pressure rise, such as when the user stops applying suction to the cigarette **10**.

In another embodiment, the user may engage a switch in the cigarette **10** that may activate the electrical energy supply to the heating element **24** and produce the temperature desired for vaporization.

The stored energy tends to be a limiting design parameter in micro-vaporizer. A battery is a typical energy storage device. Batteries may be inexpensive, provide long term energy storage, portable, be small in size and provide immediate electrical power. These characteristics are generally beneficial for electronic cigarettes and other types of personal vaporizers. The batteries may be rechargeable or non-rechargeable. If rechargeable, a battery charging holder may be provided to store the cigarette. If the battery is replaceable, the housing for the battery may be removable from the proximal portion of the cigarette.

Minimizing the amount of stored energy needed in a micro-vaporizer can assist in reducing the cost of energy, reducing the size of the cigarette, extending the period of cigarette operation, and reducing the period between when suction is applied to the cigarette and vapor is inhaled.

Small cylindrical batteries, such as AAA batteries, are in widespread use and provide an inexpensive source of electrical energy for an electronic cigarette. AAA batteries have a diameter similar to the diameter of a conventional tobacco cigarette. An electronic cigarette with a single AAA battery may have a diameter, length and size similar to a conventional tobacco cigarette. Alkaline AAA batteries are inexpensive and are cheaper than lithium AAA batteries. Rechargeable AAA batteries are also widely available. Accordingly, AAA batteries, especially alkaline batteries, may be suitable for electronic cigarettes and other micro-vaporizers.

A potential short-coming of AAA batteries and other similarly small batteries is their relatively slow energy discharge capacity. The stored energy in the cigarette should be sufficient to power the heating element during an entire smoking session. The amount of energy stored and required energy discharge rate in a conventional alkaline AAA battery may be insufficient to power a cigarette during an entire smoking session. While a lithium AAA battery may provide sufficient energy for a smoking session, these types of batteries are expensive particularly for disposable cigarettes.

By controlling the amount of liquid applied to a heating element, adjusting the heating element temperature production accordingly, and vaporizing the liquid at an efficient manner, the invention may reduce the energy required in the vaporization process to enable the use of a simple and inexpensive conventional battery in an electronic cigarette.

Advantages of the embodiment designs may include: improving thermal efficiency in vaporizing liquid and producing an adequate amount of desired vapor that does not produce condensation; providing a user the ability to control the amount of vapor desired to be produced; preventing vapor condensation due to excess vapor produced; preventing fluid leakage due to vibrations on the device or environmental changes, such as temperature changes, that may cause an in-balance in pressure in the liquid reservoir of a device; ability for the device to be used in any orientation and still be able to provide adequate fluid supply to the heating element; and providing a simple structure that may be made close to or approximately the size of a conventional tobacco cigarette if desired.

While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. A personal vaporizer comprising:

a mouthpiece having an air passage;

a vaporization chamber sealed except for an opening to the air passage of the mouthpiece, an opening to an air duct open to the atmosphere and an opening to a liquid reservoir;

a heating element within the vaporization chamber;

a liquid storage chamber, separate from the vaporization chamber, wherein the liquid storage chamber contains atmospheric air and maintains at atmospheric pressure by being open to the atmosphere;

the liquid reservoir is a collapsible bladder and is adapted to contain a liquid at an atmospheric pressure, wherein the bladder is configured to shrink under atmospheric pressure as liquid is drawn from the bladder; and

a liquid transport device proximate to the heating element and coupled to the opening to the liquid reservoir, but does not extend into the liquid reservoir.

2. The personal vaporizer as in claim **1** further comprising a housing enclosing the vaporization chamber, liquid reservoir and a battery, wherein the housing is connected to the mouthpiece.

3. The personal vaporizer of claim **2** wherein the housing is cylindrical, and the housing has a length of between about 75-120 mm, and a diameter of no greater than 12 mm.

4. The personal vaporizer in claim **1** further comprising a one-way valve coupled to the liquid transport device and the opening to the liquid reservoir.

5. The personal vaporizer of claim **1**, wherein the vaporizer is substantially cylindrical.

6. The personal vaporizer of claim **1** further comprising a mouthpiece membrane in the air passage of the mouthpiece, wherein the membrane is formed of at least one of a porous material, a non-fibrous material, a woven material, a non-woven fibrous material, and a highly absorbent breathable material.

7. The personal vaporizer of claim **6**, wherein the mouthpiece membrane has the capability to absorb up to ¼ of the liquid amount based on the total liquid volume of the liquid reservoir.

8. The personal vaporizer of claim **6**, wherein the mouthpiece membrane is disc shaped, rectangular shaped, triangular shaped, or a combination thereof, and fills an interior diameter of the mouthpiece entirely.

9. The personal vaporizer of claim **1**, wherein the opening to the air passage of the mouthpiece has a throat diameter greater than a throat diameter of the air duct.

10. The personal vaporizer of claim **1**, wherein the opening to the air passage of the mouthpiece has a throat diameter of at least 3 mm and a throat diameter of the air duct of no greater than 3 mm.

11. The personal vaporizer of claim **1**, wherein the liquid transport device and a one-way valve coupled to the liquid transport device are configured to allow fluid flow based on reduced air pressure induced in the mouthpiece.

12. The personal vaporizer of claim **11**, wherein the liquid transport device and the one-way valve allow an amount of fluid flow that is directly related to the amount of pressure difference induced in the mouthpiece.

13. The personal vaporizer of claim **11**, wherein the reduced pressure is applied by a user applying suction to the mouthpiece.

14. The personal vaporizer of claim **1**, wherein the liquid reservoir is filled with only liquid and shrinks as liquid depletes from the reservoir.

15. The personal vaporizer of claim **1**, wherein the liquid transport device includes an opening for liquid flow that is less than 2.5 mm.

16. An electronic cigarette comprising:

a mouthpiece of an electronic cigarette having: and

a mouthpiece casing;

a mouthpiece opening at a first end of the mouthpiece casing;

a proximal housing support at a second end of the mouthpiece casing;

a mouthpiece membrane between the mouthpiece opening and the proximal housing support, and

a vaporization chamber defined by the mouthpiece casing, the mouthpiece membrane, and the proximal housing support, the vaporization chamber including:

a heating element;

a liquid transport device located in close proximity to the heating element, and through the proximal housing support;

a one-way valve connected to the liquid transport device, and

an opening in the proximal housing support that is configured to brace an air duct;

a proximal cylindrical housing section operatively connected to a side of the proximal housing support opposite from the mouthpiece casing, the proximal cylindrical housing section having:

a proximal cylindrical housing casing, having a first end that is operatively connected to the proximal housing support, and a second end that is operatively connected to a distal housing support;

a liquid storage chamber defined by the proximal housing support, the proximal cylindrical housing casing, and the distal housing support;

an air duct operatively connected to an opening in the proximal housing support that is configured to communicate between the liquid storage chamber and the vaporization chamber; and

a liquid reservoir operatively connected to the liquid transport device through the proximal housing support that supplies liquid to the liquid transport device.

17. The electronic cigarette of claim **16**, wherein the electronic cigarette has a length of between about 75-120 mm, and a diameter of about 10 mm.

18. The electronic cigarette of claim **16**, wherein the electronic cigarette is substantially cylindrical.

19. The electronic cigarette of claim **16**, wherein the mouthpiece opening is hollow and allows vapor to pass from the electronic cigarette into a mouth of a user.

20. The electronic cigarette of claim **16**, wherein the mouthpiece membrane is made of one of a porous material, a non-fibrous material, a woven material, a non-woven fibrous material, a highly absorbent breathable material, or a combination thereof.

21. The electronic cigarette of claim **16**, wherein the mouthpiece membrane is configured to have the capability to absorb up to ¼ of the liquid amount based on the total liquid volume of the liquid reservoir.

22. The electronic cigarette of claim **16**, wherein the mouthpiece membrane is disc shaped, rectangular shaped, triangular shaped, or a combination thereof, and fills an interior diameter of the mouthpiece entirely.

23. The electronic cigarette of claim **16** further comprising a vent in the distal cylindrical housing section.

24. The electronic cigarette of claim **16**, wherein the distal housing support is configured to allow air communicate between the distal cylindrical housing section and the proximal cylindrical housing section.

25. The electronic cigarette of claim **16**, wherein the liquid transport device and the one-way valve are configured to allow fluid flow in one direction only.

26. The electronic cigarette of claim **16**, wherein the liquid transport device and the one-way valve are configured to allow fluid flow based on an amount of air pressure difference induced in the mouthpiece.

27. The electronic cigarette of claim **26**, wherein the liquid transport device and the one-way valve allow an amount of fluid flow that is directly related to the amount of pressure difference induced in the mouthpiece.

28. The electronic cigarette of claim **16**, wherein the liquid transport device includes an opening that is less than 2.5 mm.

29. The electronic cigarette of claim **26**, wherein the amount of pressure induced is controlled by a user of the electronic cigarette by applying an amount of suction force on the mouthpiece opening.

30. The electronic cigarette of claim **16**, wherein the liquid reservoir is collapsible or shrinkable.

31. The electronic cigarette of claim **16**, wherein the liquid reservoir is a bladder that is made of a plastic, a little or non-elastic thin film.

32. The electronic cigarette of claim **16**, wherein the liquid reservoir is filled with only liquid, without any gases, and may collapse or shrink as liquid depletes from the reservoir.

33. The electronic cigarette of claim **16**, wherein the liquid reservoir is only open to the atmosphere at an opening operatively connected to the liquid transport device and one-way valve.

34. The electronic cigarette of claim **16**, wherein the opening in the liquid transport device is less than or about 1 mm in diameter.

35. The electronic cigarette of claim **16** further comprising a distal cylindrical housing section operatively connected to a side of the distal housing support opposite from the proximal cylindrical housing casing.

36. The electronic cigarette of claim **35** further comprising a battery in the distal cylindrical housing section.

37. A liquid transport device in an electronic cigarette comprising:

a support body of a liquid transport device;

a cavity on a first side of the support body;

an opening in the cavity that provides fluid communication between a first side of the support body and a second side of the support body;

a plunge valve, and

a bleed valve

wherein the cavity is adapted to be situated in close proximity to the heating element; and

wherein the liquid transport device is adapted to draw an amount of liquid from the first side of the support body to the second side of the support body through the opening to supply the amount of liquid to the heating element, the amount of liquid includes an amount that is less than the amount needed to form a liquid droplet, the droplet being a small quantity of the liquid formed as a spherical mass at atmospheric pressure.

38. The liquid transport device of claim **37**, wherein the plunge valve supplies liquid to the heating element.

39. The liquid transport device of claim **37**, wherein the bleed valve releases air when air pressure difference induced in the electronic cigarette exceeds a maximum air pressure threshold.

40. A micro-vaporizer comprising:

a mouthpiece having an air passage;

a vaporization chamber sealed except for an opening to the air passage of the mouthpiece, an opening to an air duct and an opening to a liquid reservoir; and

a liquid storage chamber housing the air duct and the liquid reservoir, operatively connected to the vaporization chamber;

wherein the vaporization chamber is adapted to have a lower pressure than the liquid storage chamber, and

wherein the air duct is adapted to communicate between the vaporization chamber and the liquid storage chamber.

41. The micro-vaporizer of claim **40**, wherein the vaporization chamber and the liquid storage chamber have a pressure difference.

42. The micro-vaporizer of claim **40**, wherein pressure in the vaporization chamber is lowered by a user applying a suction force on the mouthpiece air passage.

43. The micro-vaporizer of claim **40**, wherein an amount of liquid is drawn from the opening of the liquid reservoir when a lower pressure is induced in the vaporization chamber as compared to the pressure in the liquid storage chamber and the liquid reservoir.

44. The micro-vaporizer of claim **43**, wherein the amount of liquid drawn from the liquid reservoir is proportional to the pressure difference between the vaporization chamber and the liquid storage chamber.

45. A micro-vaporizer comprising:

a mouthpiece having an air passage;

a vaporization chamber sealed except for an opening to the air passage of the mouthpiece, an opening to an air duct and an opening to a liquid reservoir; and

a liquid storage chamber housing the air duct and the liquid reservoir, operatively connected to the vaporization chamber;

wherein the vaporization chamber is adapted to have a lower pressure than the liquid storage chamber, and

wherein the air duct is adapted to equalize the pressure difference between the vaporization chamber and the liquid storage chamber.

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